Plant Species Classification with CNN

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Abstract: Plant species recognition from images is challenging due to a large diversity of plants, variation in orientation, viewpoint, background clutter etc. In this paper, plant species recognition is carried out with the help of deep learning Convolutional Neural Network approach. CNN has been used since it has outperformed in various image recognition challenges and feature extraction is performed automatically, which takes less time. The proposed model is run for differently epochs and results were recorded. It was observed that the CNN model performed effectively in distinguishing the plant leaf images and achieved 96.95% accuracy.

Key words: Convolutional Neural Network (CNN), Image classification, deep learning, Machine learning.

I. INTRODUCTION

In agriculture, plant species identification is used for weed detection, growth estimation, and plant disease classification. Also, plants are used as medicines providing solutions to diabetes and cardiovascular diseases. In plant species recognition, leaf plays an important role compared to other parts like flower, seeds and stem. Computer vision techniques are utilized in automatic plant identification and recognition.

In a manual identification process, botanist use different plant characteristics as identification keys, which are examined sequentially and adaptively to identify plant species. Botanists do a detailed observation of plant species using their knowledge in the field and conclude the species. However, the determination of plant species from field observation requires a substantial botanical expertise, which puts it beyond the reach of most nature enthusiasts. Traditional plant species identification is almost impossible for the general public and challenging even for professionals that deal with botanical problems daily; such as, conservationists, farmers, foresters, and landscape architects. Even for botanists themselves species identification is often a difficult task. The situation is further exacerbated by the increasing short-age of skilled taxonomists. The declining and partly non-existent taxonomic knowledge within the general public has been termed “taxonomic crisis”.

The still existing, but rapidly declining high biodiversity and a limited number of taxonomists represents significant challenges to the future of biological study and conservation. Recently, taxonomists started searching for more efficient methods to meet species identification requirements, such as developing digital image processing and pattern recognition techniques. The rich development and ubiquity of relevant information technologies, such as digital cameras and portable devices, has brought these ideas closer to reality. Digital image processing refers to the use of algorithms and procedures for operations such as image enhancement, image compression, image analysis, mapping, and geo-referencing. The influence and impact of digital images on the modern society is tremendous and is considered a critical component in a variety of application areas including pattern recognition, computer vision, healthcare.

The present paper proposes a deep learning CNN model for classification of plant species. Researches have already used various conventional effective classification method such as the K-nearest neighbor, support vector machine, genetic algorithm, probabilistic neural network, and principal component analysis for plant species classification.

II. RELATED WORKS

From the leaf of the plant to the roots each and every part constitutes to the identity of a particular plant species. The classification process needs to decides which part will be an important factor for accurate results. The technology including the algorithm and classification techniques also provides different results. The researches mainly revolve around this aspects and combination of two which can be a breakthrough everyone is looking for. The Plant classification using flower images and KNN a high classification accuracy of 94 % was realized [1]. Leaf-based classification using CNN was most common classification method [2][3][4][5]. [2][3] Leaf vein can also be used as classification of the Plant Species. Using Leaf Vein Morphometric technique testing accuracy of 94.88% was achieved [2]. The 3D LASER study used six different species and was able to classify 99% of plants [3]. Another Leaf Venation Detection gives accuracy of 99% for Flavian dataset and 91% for Acer dataset [4]. The Study using technique double deep learning technique has accuracy of 99% for different datasets [5]. The classification using CNN has showed the prominent results among other techniques [2][3][4][5]. Leaf base classification and CNN is being used in our research. CNN-based classifier always has a better performance than another classifier method.
III. METHODOLOGY

A. Kaggle dataset

The Kaggle dataset [6], a freely available dataset, was used for the experiment study. This dataset contains 4242 images of plants. The data collection is based on the data flicr, google images, Yandex images. The pictures are divided into five classes: daisy, tulip, rose, sunflower, dandelion. For each class there are about 800 photos. Photos are not high resolution, about 320 x 240 pixels. Photos are not reduced to single size; they have different proportions.

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Total images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daisy</td>
<td>769</td>
</tr>
<tr>
<td>Dandelion</td>
<td>1055</td>
</tr>
<tr>
<td>Rose</td>
<td>784</td>
</tr>
<tr>
<td>Sunflower</td>
<td>734</td>
</tr>
<tr>
<td>Tulip</td>
<td>987</td>
</tr>
</tbody>
</table>

B. The Architecture of CNN model

The Convolutional Neural Network (CNN) is a prominent deep learning architecture mainly used for image classification. A CNN is a sequence of layers such as convolutional layer, subsampling layer and fully connected layer, and may include some supplementary layers. The basic units of CNN architecture are enlightened as follows:

(a) Convolutional Layer

A convolutional layer is the essential layer of CNN architecture that performs most of the convolutional operation. In the convolutional operations, we calculate the element-wise product of weight matrix (also known as kernel or filter) and image pixels. It helps to get the important features from the input image like edges of an object in the image.

(b) Activation Function

The outcome of convolution operation is surpassed through an activation function which is used to add nonlinearity to the network. A rectified linear unit (ReLU) has been used as an activation function internally in the convolutional layers. The ReLU values can be computed as $R(z) = \max (0, z)$. It is easy to calculate and provide result much faster as compared to the sigmoidal function which involves calculating exponential terms. But at the output layer, sigmoidal function has been used.

(c) Max pooling layer

It is a subsampling/downsampling layer which is usually added after the convolutional layer. It helps to reduce the redundancy present in the input features and also keep a check on overfitting. Max-pooling is used in the CNN architecture which selects the maximum value and pool into an output matrix.

(d) Fully connected layer

This is a flattening layer which results into a feature vector and the neurons have full connections with neurons in the preceding layer. Then the feature vectors are passed through multiple dense layers.

(e) Output layer

The output layer is responsible for producing probabilities of each class.
We have used sigmoidal activation function to find the final class of given input image. Fig. 2 shows the CNN architecture being used for leaf classification. Input_1 is the Input layer. Conv2d is the first convolutional layer applied on input image which is followed by a max-pooling layer, i.e., max_pooling2d (MaxPooling2D). Again, two convolution and a max-pooling layer are added. Finally, a flattening layer, i.e., Flatten and a dense layer, Dense_1 is added. Table 2 represents the generated Convolutional Neural Network model summary. It is showing different layers used in the model as well as the output shape obtained from different layers. The total parameters are 9,796,229 which all are trainable.

### Table 2

<table>
<thead>
<tr>
<th>Layer (type)</th>
<th>Output Shape</th>
<th>Param #</th>
</tr>
</thead>
<tbody>
<tr>
<td>input_1 (InputLayer)</td>
<td>([None, 224, 224, 3])</td>
<td>0</td>
</tr>
<tr>
<td>conv2d (Conv2D)</td>
<td>(None, 224, 224, 32)</td>
<td>2432</td>
</tr>
<tr>
<td>max_pooling2d (MaxPooling2D)</td>
<td>(None, 112, 112, 32)</td>
<td>0</td>
</tr>
<tr>
<td>conv2d_1 (Conv2D)</td>
<td>(None, 112, 112, 64)</td>
<td>16496</td>
</tr>
<tr>
<td>max_pooling2d_1 (MaxPooling2D)</td>
<td>(None, 56, 56, 64)</td>
<td>0</td>
</tr>
<tr>
<td>conv2d_2 (Conv2D)</td>
<td>(None, 56, 56, 96)</td>
<td>55392</td>
</tr>
<tr>
<td>max_pooling2d_2 (MaxPooling2D)</td>
<td>(None, 28, 28, 96)</td>
<td>0</td>
</tr>
<tr>
<td>conv2d_3 (Conv2D)</td>
<td>(None, 28, 28, 96)</td>
<td>83040</td>
</tr>
<tr>
<td>max_pooling2d_3 (MaxPooling2D)</td>
<td>(None, 14, 14, 96)</td>
<td>0</td>
</tr>
<tr>
<td>flatten (Flatten)</td>
<td>(None, 18816)</td>
<td>0</td>
</tr>
<tr>
<td>dense (Dense)</td>
<td>(None, 512)</td>
<td>9634304</td>
</tr>
<tr>
<td>dense_1 (Dense)</td>
<td>(None, 5)</td>
<td>2565</td>
</tr>
</tbody>
</table>

Total params: 9,796,229
Trainable params: 9,796,229
Non-trainable params: 0

We have used sigmoidal activation function to find the final class of given input image. Fig. 2 shows the CNN architecture being used for leaf classification. Input_1 is the Input layer. Conv2d is the first-convolutional layer applied on input image which is followed by a max-pooling layer, i.e., max_pooling2d (MaxPooling2D). Again, two convolution and a max-pooling layer are added. Finally, a flattening layer, i.e., Flatten and a dense layer, Dense_1 is added. Table 2 represents the generated Convolutional Neural Network model summary. It is showing different layers used in the model as well as the output shape obtained from different layers. The total parameters are 9,796,229 which all are trainable.

### IV. PERFORMANCE AND OUTPUT

#### A. Performance

The proposed work provides a way to classify 5 different species of plants using a convolutional neural network. The implementation of CNN is done in python language. The python code was executed for a various round of epochs to record corresponding accuracy and losses. The best accuracy 96.65 which is obtained in the 10th epoch. Fig. 3 and 4 shows the loss and accuracy curve on the proposed CNN model.
B. Output

The model accuracy was found out to be as 96.95%, and the test loss is 0.1140. The result of the experiment can be seen with the help of below figure. Below figure shows the expected output with the actual input.

Fig. 3-Model Accuracy  
Fig. 4-Model Loss

V. CONCLUSION

Here, we successfully demonstrated a model that can recognize the plant species. It is assumed that the result can be more accurate if we use predefined Zoo model such as Inception V3 or Faster-RCNN. In the future, we plan to increase the accuracy by expanding the size of the dataset. As of now, our application can only classify 5 plant species. In future, we will further extend this application, so that it can classify more plants.

REFERENCES


